INTERHEMISPHERIC DIFFERENCES OF HAND MOTOR CORTEX ORGANIZATION: MEG-EMG CORTICO-MUSCOLAR COHERENCE

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Abstract - **Corticomuscular coherence between cerebral cortical rhythms and the surface electromyography (EMG) has been observed both trough electrocorticogram and by electroencephalographic (EEG) and magnetoencephalographic (MEG) recordings.**

Corticomuscular coherence is a tool for identification and characterization of cortical districts controlling a particular body district, based on amplitude and frequency selection. MEG recordings of parietal contralateral cerebral activity and muscular activity from right and left extensor comunis digitorum (ECD) have been studied in 5 control subjects (bandpass 0.48-250 Hz, sampling rate 1000 Hz).

Subject was required to contract separately left and right ECD, with 50% of maximal voluntary contraction force, for periods of 1-1.5 min. MEG-EMG coherence has been evaluated by Welch method, by windowing (Hamming) the artifact free signal in tracts lasting 2048 pt, overlapped by 60%. Tracts with high coherence were selected.

Confidence limit was calculated and coherence levels above this value considered for motor control characterization. Comparison between dominant - non dominant hemispheric frequency coherence spectra and spatial coherence distribution has been performed.

Preliminary results indicate in dominant hemisphere, a more concentrated frequency distribution in the coherence spectrum (higher values in a sharper frequency range) and, once selected the coherence at peck value, a more concentrated spatial distribution.

Methodological optimization of the coherence procedure are discussed.

These indications of dominant-non dominant hemispheric asymmetries could be feather investigated to establish physiological parameters to identify eventual alterations in the cortical motor organization induced by pathological conditions.

Keywords - **MEG, EMG coherence, Inter-hemispheric differences.**

I. INTRODUCTION

Coherence between cerebral cortical rhythms and surface electromyography (EMG) was first observed in the gamma band (32 Hz) using electrocorticography.

More recently also magnetoencephalography (MEG) has provided evidence of such coherence, in particular within the beta band (13-35 Hz) during weak- and medium-voluntary contraction using axial gradiometers and in both beta and gamma (40 Hz range) bands during strong-voluntary contraction using planar gradiometers [1,2]. Although neuronal firing rate can increase up to several hundreds per second and typical surface EMG shows activity up to 100-200 Hz, voluntary muscular contraction activity is regulated by motor unit (MU) recruitment, which operates in the 6-35 Hz range.

In order to extract grouped MU activity we used the rectified surface EMG: this shows significant signal below 80 Hz, the three most important ones peaking at approximately 10, 20, and 40 Hz: alfa and beta activities

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characterize cerebral rhythms in cortical sensorimotor areas.

Two main aspects are related to corticomuscular coherence: the ability of localizing the cortical districts controlling a particular body district [3,4] based on amplitude and frequency selection, and temporal information about conduction times of the rhythmic drive from motor cortex to motor neuron pools based on the phase difference dynamics [3].

In the present study, EMG-MEG coherence was evaluated in both hemispheres during extension of the contralateral hand in order to evaluate the interhemispheric characteristics of the motor cortex organization.

II. SUBJECTS AND METHODS

MEG recordings of parietal contralateral cerebral activity and muscular activity from right and left extensor comunis digitorum (ECD) have been studied in 5 control subjects (bandpass 0.48-250 Hz, sampling rate 1000 Hz). Subjects were required to contract separately left and right ECD, with 50% of maximal voluntary contraction force, for periods of 45-60 sec. MEG-EMG coherence was evaluated by Welch method, by windowing (Hamming) the artifact free signal in tracts lasting 2048 points, with 60% overlapping.

Confidence limit was calculated and coherence levels above this value was considered for motor control characterization.

Moreover in the same cerebral region, the response to somatosensory stimulation (somatosensory evoked fields = SEF) of the contralateral median nerve has been recorded.

Hemispheric frequency coherence spectra were compared in order to check for differences between the dominant and the non-dominant hemispheres.

Channels with maximal coherence were selected in each hemisphere, and the difference among the two were evaluated in terms of bandwidth and amplitude.

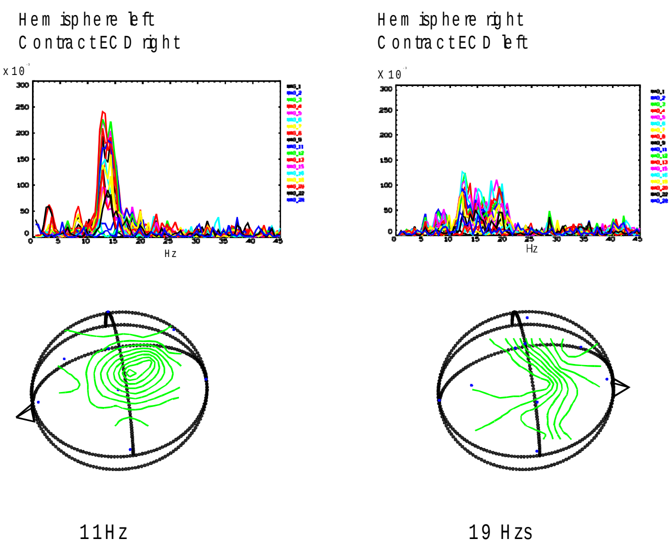
At the frequency point of maximal coherence in each hemisphere, the spatial distribution in the parietal region has been considered: comparison was performed between the distributions in the two hemispheres, and between motor coherence with respect to somatosensory organization

III. RESULT

No significant coherence (all values above confidence limit level) was found between MEG signals and EMG activity of the non-contracted muscle.

Comparison between somatosensory cortex, as evaluated by the spatial distribution at the latency of the primary somatosensory activation, and motor cortex organizazion, as described by the coherence spatial distribution, showed more anterior location of the former with respect to the latter.

Preliminary results indicate a more concentrated frequency distribution of the coherence spectrum in the dominant hemisphere (Fig): in fact, higher values resulted in a sharper frequency range during the extension of the contralateral hand. Furthermore, once



selected the frequency value of maximal coherence, the spatial coherence distribution proved to be more concentrated (Fig).

IV. DISCUSSION

More anterior location of the coherence spatial distribution with respect to somatosensory cortical representation agrees with MEG-EMG coherence method for spatially describing motor cortex organization. Present indications seem to define different features of the dominant with respect to the non dominant hemisphere, in particular showing more concentrated motor hand cortical representation both as coherence frequency spectrum and spatial distribution in the dominant hemisphere.

These indications of dominant - non dominant hemispheric asymmetries will be evaluated in right-handed, left-handed and bimanual subjects.

Moreover, they could be further investigated to establish physiological parameters to identify possible alterations in the cortical motor organization induced by pathological conditions.

Methodological optimization of the coherence procedure is intended to be achieved through developing a suitable method for selection of tracts with high coherence.

This recently developed analysis method could add deep insight into the cortical mechanisms and could help discriminating cortical from spinal levels motor control.

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